

IN THE U.S. PATENT AND TRADEMARK OFFICE

In re application of

Dirk-Olaf LEIMAN

Conf. 1793

Application No. 10/506,986  
(PCT/IB03/00791)

Group unknown

Filed September 9, 2004

Examiner unknown

GEAR UNIT

RESPONSE TO NOTIFICATION OF MISSING REQUIREMENTS

Assistant Commissioner for Patents  
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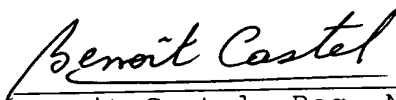
Sir:

In response to the accompanying Notification of Missing Requirements Under 35 U.S.C. 371 mailed February 15, 2005, we enclose herewith the executed declaration in compliance with 37 CFR 1.497.

The required 37 CFR 1.492(e) surcharge was paid at the time of filing the application.

Respectfully submitted,

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April 15, 2005



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CONFIRMATION NO. 1793

371 FORMALITIES LETTER



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**NOTIFICATION OF MISSING REQUIREMENTS UNDER 35 U.S.C. 371 IN THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)**

The following items have been submitted by the applicant or the IB to the United States Patent and Trademark Office as a Designated / Elected Office (37 CFR 1.495).

- Copy of the International Application filed on 09/09/2004
- Copy of the International Search Report filed on 09/09/2004
- Copy of IPE Report filed on 09/09/2004
- Preliminary Amendments filed on 09/09/2004
- Information Disclosure Statements filed on 09/09/2004
- Request for Immediate Examination filed on 09/09/2004
- Copy of references cited in ISR filed on 09/09/2004
- U.S. Basic National Fees filed on 09/09/2004
- Priority Documents filed on 09/09/2004

The following items **MUST** be furnished within the period set forth below in order to complete the requirements for acceptance under 35 U.S.C. 371:

- Oath or declaration of the inventors, in compliance with 37 CFR 1.497(a) and (b), identifying the application by the International application number and international filing date.

**ALL OF THE ITEMS SET FORTH ABOVE MUST BE SUBMITTED WITHIN TWO (2) MONTHS FROM THE DATE OF THIS NOTICE OR BY 32 MONTHS FROM THE PRIORITY DATE FOR THE APPLICATION, WHICHEVER IS LATER. FAILURE TO PROPERLY RESPOND WILL RESULT IN ABANDONMENT.**

The time period set above may be extended by filing a petition and fee for extension of time under the provisions of 37 CFR 1.136(a).

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

*A copy of this notice **MUST** be returned with the response.*

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**PART 2 - OFFICE COPY**

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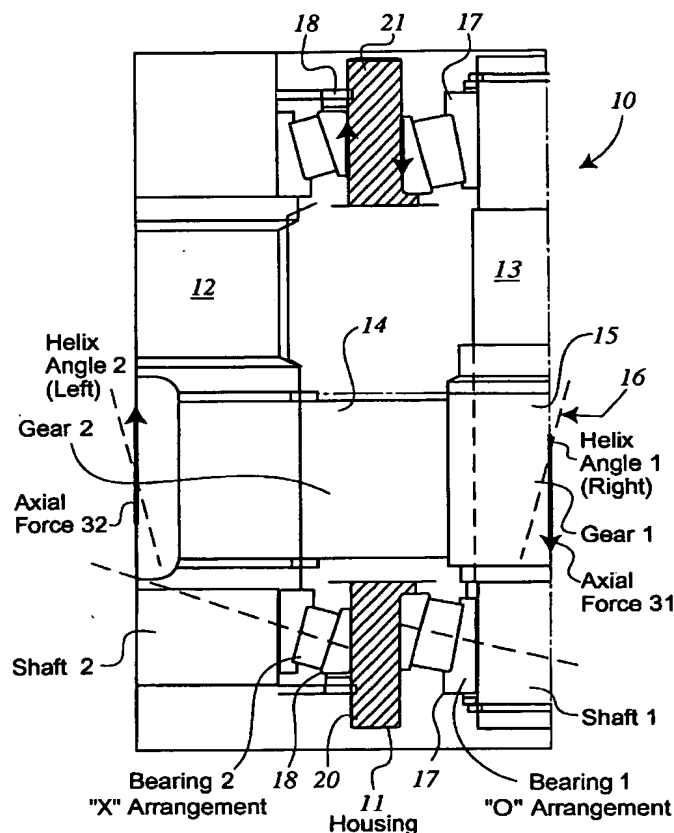
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[Continued on next page]

(54) Title: **GEAR UNIT**



(57) Abstract: A gear unit comprising a housing, two shafts arranged parallel with one another and each supporting a helically cut toothed gear, and two pairs of bearings supported by or relative to the housing in an arrangement in which each pair of bearings rotatably supports a shaft with the toothed gears of the two shafts being rotatable one relative to the other in mutual engagement, wherein two bearings of the two shafts lying to a common side of the inter-engaged helical gears are supported by a substantially common wall section of the gear unit housing, one of said two bearings being arranged to transmit to said housing wall section axial forces acting in a direction from the gears to the bearing and the other bearing being arranged to transmit to said wall section axial forces acting in a direction from said other bearing to the gears. The said two bearings of the two shafts lying to a common side of the inter-engaged helical gears may be taper roller bearings and the bearings of one shaft may be arranged in the manner of X type bearing configuration whilst the bearings of the other shaft may be arranged in an O type configuration.



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ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,  
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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

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## GEAR UNIT

This invention relates to a gear unit and in particular, though not exclusively, to a gear unit comprising at least one pair of parallel shafts and a pair of helical gears.

Although helical gears provide a smoother and quieter transmission of torque between two rotatable shafts, they inherently tend to generate axial forces acting in the direction of the axis about which a gear rotates.

The axially generated forces created when helical gears transmit torque act on the gear unit housing via shaft support bearings. The resulting deformation of the gear unit housing has an adverse effect on the axial clearance or preload of the support bearings. Particularly in the case of bearings of the taper roller type that can have a significant adverse effect on the bearing performance and life, and potentially also an adverse effect on the smoothness and general performance of the helical gears.

It is well known that the axial forces can be avoided by providing a pair of helical gears on a common shaft with one gear of the pair comprising teeth which extend helically in a direction opposite to the teeth of the other gear of the pair. That, however, often is not a satisfactory solution because of additional costs and restriction on other aspects of the gear unit design.

Another technique which may be employed to minimise the effect of axial forces on bearing clearance and preload is to selectively strengthen the housing wall so that it is better able to resist significant deflection. That, however, requires the use of additional material, thereby increasing weight and cost as well as overall dimensions.

One object of the present invention is to provide a gear unit which is better able to resist the effect of axial forces arising in a pair of parallel shafts.

In accordance with one aspect of the present invention a gear unit comprises a housing, two shafts arranged parallel with one another and each supporting a helically cut toothed gear, and two pairs of bearings supported by or relative to the housing in an arrangement in which each pair of bearings rotatably supports a shaft with the toothed gears of the two shafts being rotatable one relative to the other in mutual engagement, wherein two bearings of the two shafts lying to a common side of the inter-engaged helical gears are supported by a substantially common wall section of the gear unit housing, one of said two bearings being arranged to transmit to said housing wall section axial forces acting in a direction from the gears to the bearing and the other bearing being arranged to transmit to said wall section axial forces acting in a direction from said other bearing to the gears.

The other two bearings, typically lying to the other side of the inter-engaged helical gears, may be similarly arranged such that a second wall section of the housing, opposite the aforementioned wall section, may be acted on simultaneously by opposing axial forces exerted by the two shafts. The bearings preferably are each of a type, or arranged, such that for each of the two shafts, axial forces acting in one direction are transmitted to a housing wall section by only one of the two bearings of that shaft. If any axial forces of that shaft act in an opposite direction (e.g. if the shafts are provided with helical gears of a reversed helix angle) those forces may be transmitted to a wall section only by the other of the two bearings of that shaft.

Each of said bearings may be of a type known per se, for example it may comprise ball bearings, cylindrical or spherical roller bearings.

The bearings of one of the two shafts may be arranged in the manner of an X type bearing configuration in which axial forces are transmitted from an inner ring to an outer ring, and therefore to a housing wall section in a direction away

from the gears, and the bearings of the other shaft are disposed in the equivalent of an O type configuration, with axial forces being transmitted from the inner ring to the outer ring and thus to a housing wall section in a direction from the bearing towards the gears.

A particularly suitable type of bearing is a taper roller bearing, and the bearings of one of the two shafts may be arranged in an O configuration and those of the other shaft in an X configuration.

Accordingly the present invention provides also a gear unit comprises a housing, two shafts arranged parallel with one another and each supporting a helically cut toothed gear, and two pairs of taper roller bearings supported by or relative to the housing in an arrangement in which each pair of bearings rotatably supports a shaft with the toothed gears of the two shafts being rotatable one relative to the other in mutual engagement, the pair of taper roller bearings of one shaft being provided axially spaced in an O configuration in which the diameter of the bearing rollers of each bearing increases progressively in the direction away from the other bearing of the pair, and the taper roller bearings of the other shaft being provided axially spaced in an X configuration in which the diameter of the bearing rollers of each bearing decreases progressively in the direction away from the other bearing of the pair.

An arrangement of a pair of axially spaced taper roller bearings in which the bearing rollers of one bearing increase in diameter in a direction away from the other bearing of the pair is referred to as an O bearing configuration. An arrangement of a pair of axially spaced bearings in which the bearing rollers of one bearing decrease in diameter in a direction away from the other bearing of the pair is referred to as an X bearing configuration.

The invention envisages that each shaft may have a helical gear thereof positioned axially between the bearings of that shaft, and that the bearings of a



pair are positioned respectively in substantially mutually opposite wall sections of the housing.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which: -

Figure 1 is a sectional view of part of a gear unit accordance with the present invention;

Figure 2 is a sectional view of part of another gear unit in accordance with the present invention, and

Figure 3 is a sectional view of a multi-stage gear unit in accordance with the present invention.

A gear unit 10 (see Figure 1) comprises a housing 11 having mutually opposite side wall sections 20, 21 and two mutually parallel shafts 12, 13. The shaft 12 has secured thereto a helically cut toothed gear 14 and the shaft 13 is provided with a helically cut pinion gear 15. The line of action of inter-engaging gear teeth is shown by the line 16 in the accompanying drawing.

Shaft 12 is rotatably supported relative to the housing 11 by a pair of axially spaced taper roller bearings 18, the bearings of that pair being located respectively in the opposite side wall sections 20, 21 of the housing 11. The bearings 18 are arranged in an X configuration in which the diameter of each bearing roller decreases in the direction away from the other bearing of the pair.

The shaft 13 is similarly rotatably supported relative to the housing by means of a pair of axially spaced taper roller bearings 17, except that the bearings of this pair are mounted in a reverse manner, in an O configuration.

In use of the aforescribed gear unit, when torque is transmitted between the gears 14, 15, there results an axial force 31 on the shaft 13 and an axial force 32 on the shaft 12. Reaction forces to counter the axial forces 31, 32 are

transmitted to a common wall section, section 21, by virtue of the orientation of the taper roller bearings. Thus, in contrast to a conventional gear arrangement in which the mutually parallel shafts are supported by pairs of bearings each arranged in the same O or X configuration, which results in the reaction forces being carried by opposite wall sections, and consequential deformation of the wall sections relative to one and another, by the present invention the reaction forces act at a common wall section and thus do not result in any adverse effect on bearing clearance or preload.

Figure 2 shows two shafts 40,41 each carrying a helically cut gear 42,43, the two shafts 40,41 being rotatably mounted relative a housing 44 with the two gears 42,43 in mutual inter-engagement to transmit torque therebetween.

Each shaft is rotatably supported relative to a wall section of the gear unit housing 44 by a pair of cylindrical roller bearings respectively disposed at opposite sides of the gears 42,43, i.e. at opposites sides of a notional middle line 45 as shown in Figure 2. Each of the four cylindrical bearings is of the kind which can transmit axial forces in one direction in addition to radial forces.

The bearings 50,51 of the shaft 40 are arranged in a manner equivalent to an X type configuration such that axial forces in a direction from the middle line 45 to the bearing 50 are resisted by that bearing, whereas axial forces acting in the opposite direction, towards the bearing 51, and arising when the direction of rotation of the gear unit 42 is reversed, act on said bearing 51. In contrast, for the shaft 41 the two bearings 52,53 are arranged in a manner equivalent to an O type configuration. Thus for the bearing 52, axial forces are transmitted from the inner to the outer ring of the bearing in the case of axial forces acting a direction from the bearing 52 to said middle line 45. Bearing 53 similarly transmits to the housing 44 forces acting in a direction from the bearing 53 to said middle line 45. In consequence, that section of the housing wall common to the region of the

bearings 50,52 experiences substantially equal and opposite forces from the shafts 40,41 and similarly, if use is made of gears 42,43 of a reversed helix angle, the housing wall section common to the bearings 51,53 likewise experiences substantially equal and opposite axial forces from the shafts 40,41.

The present invention can be applied also to a multistage gear unit. Figure 3 shows a three stage gear unit 60 comprising a housing 61 in which four shafts 62,63,64,65 are rotatably supported by means of roller bearings. Shaft 62 is rotatably supported by a pair taper roller bearings 66 arranged in an X configuration, or alternatively by a pair of cylindrical bearings 66' arranged also in an X configuration (as shown on alternative shaft section 62') and which can transmit axial forces in one direction in addition to radial forces. Shaft 63 is rotatably supported by a pair of taper roller bearings 67 in an O configuration. The two shaft 64, 65 are each similarly supported by pairs of taper roller bearings 68,69 arranged in an O configuration.

The main axial forces arising in the respective shafts are experienced by the low speed shaft 62. These axial forces, as exerted on one of the housing wall sections 70,71 at either side of the gear unit depending on the orientation of the helix angle of the gear teeth, are therefore countered by axial forces in the neighboring shaft 63. Thus the effective axial shaft forces acting on the housing are substantially reduced as compared with a configuration in which all of the shafts are, for example, mounted by taper roller bearings in an O configuration.

Whilst the invention has been described in respect of each shaft being supported solely by one pair of bearings, it is to be understood that each shaft could be supported by additional pairs of bearings, typically all bearings on the shaft being of the same O or X configuration. Additionally, auxiliary bearing support may be provided by, for example, roller or spherical bearings which may be in combination with taper roller bearings.

## CLAIMS

1. A gear unit comprising a housing, two shafts arranged parallel with one another and each supporting a helically cut toothed gear, and two pairs of bearings supported by or relative to the housing in an arrangement in which each pair of bearings rotatably supports a shaft with the toothed gears of the two shafts being rotatable one relative to the other in mutual engagement, wherein two bearings of the two shafts lying to a common side of the inter-engaged helical gears are supported by a substantially common wall section of the gear unit housing, one of said two bearings being arranged to transmit to said housing wall section axial forces acting in a direction from the gears to the bearing and the other bearing being arranged to transmit to said wall section axial forces acting in a direction from said other bearing to the gears.
2. A gear unit according to claim 1 wherein said two bearings of the two shafts lying to a common side of the inter-engaged helical gears are taper roller bearings.
3. A gear unit according to claim 1 or claim 2 wherein the bearings of one shaft are arranged in the manner of an X type bearing configuration and the bearings of the other shaft are arranged in an O type configuration.
4. A gear unit comprising a housing, two shafts arranged parallel with one another and each supporting a helically cut toothed gear, and two pairs of taper roller bearings supported by or relative to the housing in an arrangement in which each pair of bearings rotatably supports a shaft with the toothed gears of the two shafts being rotatable one relative to the other in mutual engagement, the pair of taper roller bearings of one shaft being provided axially spaced in an O configuration in which the diameter of the bearing rollers of each bearing increases progressively in the direction away

from the other bearing of the pair, and the taper roller bearings of the other shaft being provided axially spaced in an X configuration in which the diameter of the bearing rollers of each bearing decreases progressively in the direction away from the other bearing of the pair.

5. A gear unit according to any one of the preceding claims wherein each shaft comprises a helical gear positioned axially between the pair of bearings of that shaft.
6. A gear unit according to any one of the preceding claims and comprising at least three mutually parallel shafts each provided with a helically cut toothed gear and rotatably supported in a housing by a pair of bearings, the low speed shaft being rotatably supported by bearings arranged in an X or O configuration of a type opposite the configuration of the bearings of the neighboring shaft.
7. A gear unit according to claim 6 wherein the low speed shaft is rotatably supported by bearings arranged in an X or O configuration and the gear unit comprises at least two additional shafts each rotatably supported by bearings arranged in the same configuration as one another, and opposite the configuration of the low speed shaft.
8. A gear unit according to claim 7 wherein the low speed shaft is rotatably supported by bearings arranged in an X type configuration.
9. A gear unit according to claim 1 or claim 4 and substantially as hereinbefore described.

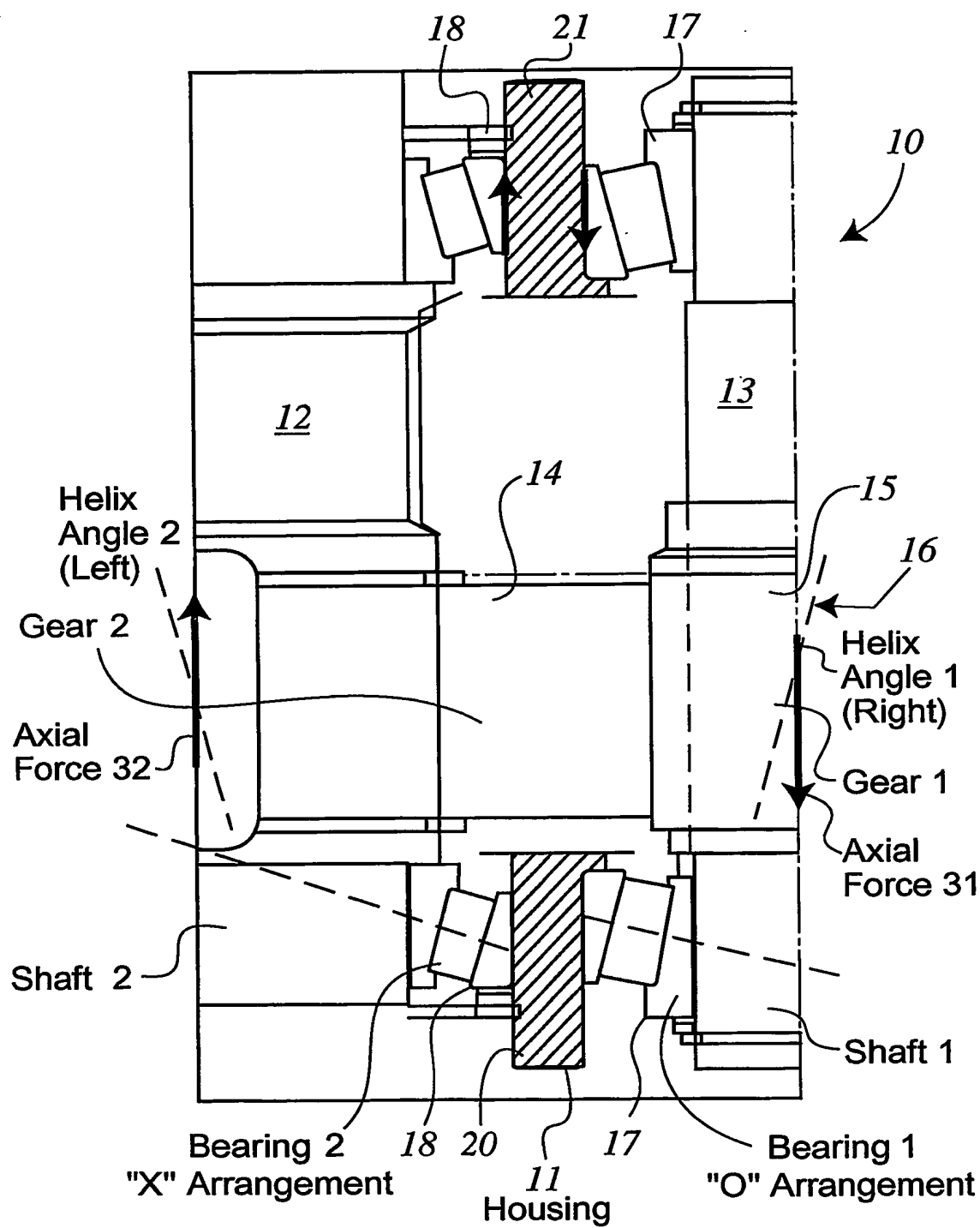
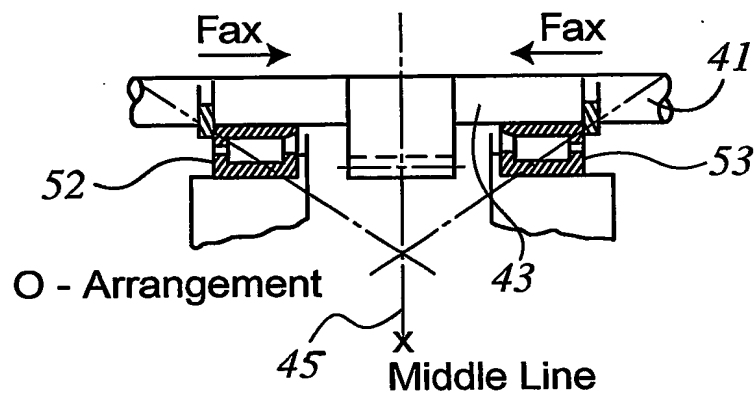
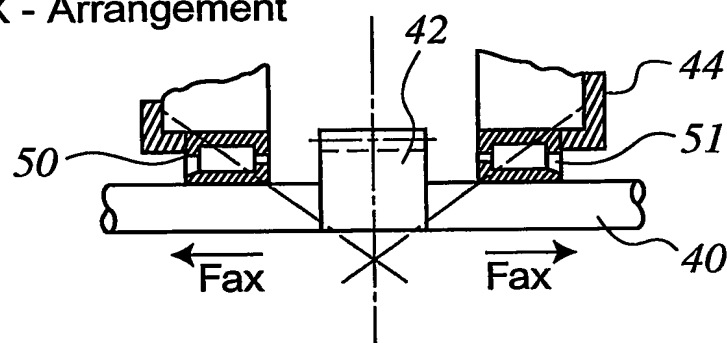
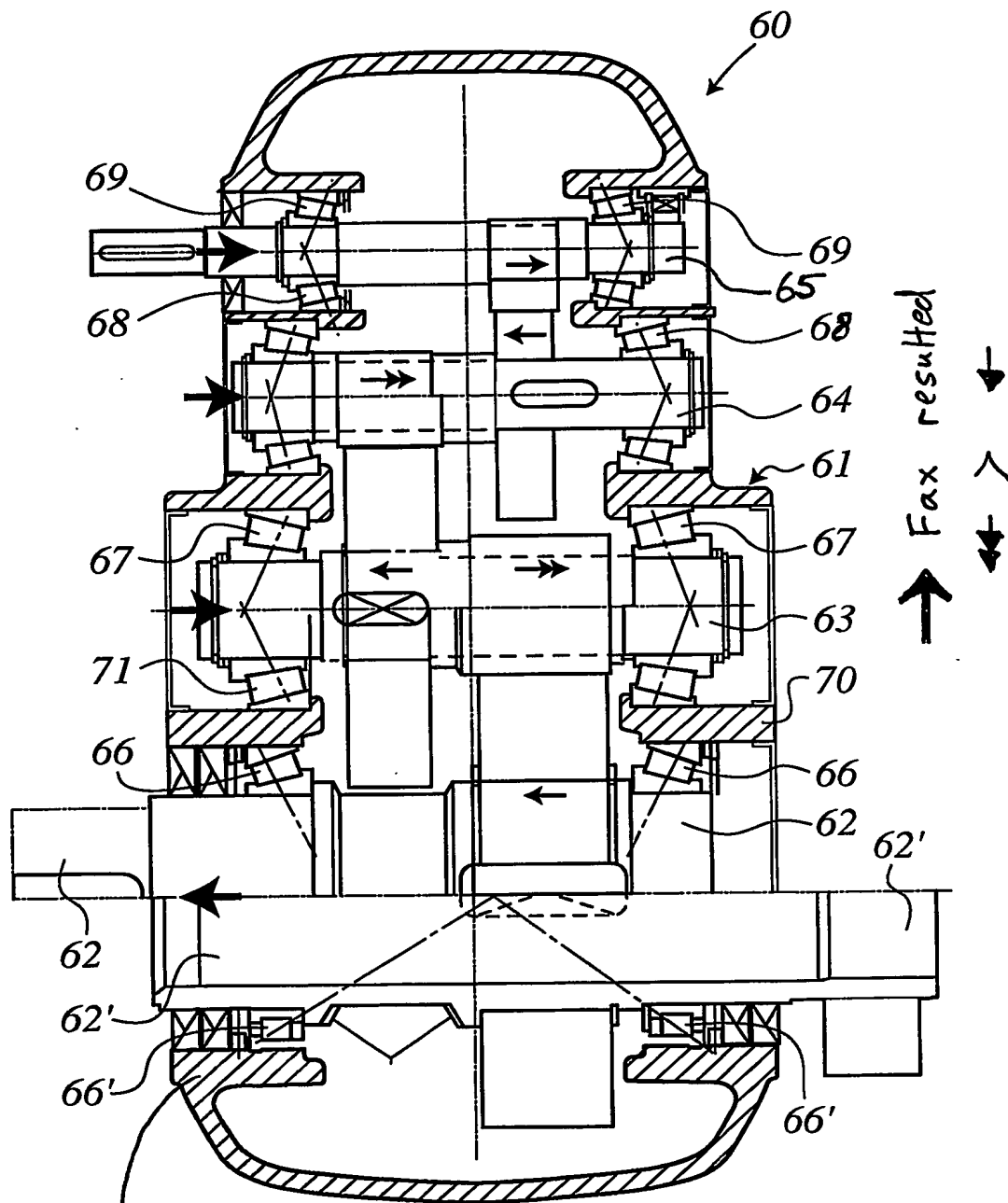


FIG. 1

With  
Cylindrical Roller Bearings  
X - Arrangement



**FIG. 2**

**FIG. 3**

Wall side who takes the axial forces  
when direction of forces are as drawn.